

RACK MOUNTABLE POWER DISTRIBUTION APPARATUS

Related Applications

This is a continuation-in-part of application serial number 09/469,978 filed December 21, 1999, the disclosure of which is incorporated in its entirety by reference herein.

Background of the Invention

5 The present invention generally relates to electrical power distribution apparatus, and more particularly relates to low cost, multi-function, rack mountable electrical power distribution apparatus and systems.

Research and development of computer technology has continually produced smaller and more compact systems. However, electrical power distribution units and systems for supplying power to electrical devices, such as computers and other critical equipment, in a building or other facility have remained bulky and sometimes difficult to work with.

Conventionally, electrical power coming into a facility passes into a free-standing power distribution unit (PDU) that includes a substantial plurality of output circuits. Each of these circuits is hard-wired to cables which are passed through conduits for distances of up to about 200 feet or more, to individual components of critical equipment. A total conduit run of up to about 3000 feet per PDU can occur. This wiring is often run through floors and walls of the facility during the electrical wiring phase of building construction. Electrical outputs initiating from such free-standing PDUs are typically provided as cables that are accessible through walls and floors of the facility.

25 Electrical needs in a building frequently change, typically by an increase in demand for more output circuits to accommodate more pieces of equipment. Power strips

including a number of plug receptacles and having a single circuit breaker may be connected to a wall receptacle. However, in many cases, a power strip is not appropriate or sufficient for large scale changes in electrical needs, or for accommodating additional pieces of critical equipment which requires hard-wired connections to the power source.

The process of re-cabling electrical output circuits from the PDU, for example, to more strategic locations within the facility, is a costly, labor intensive task, which typically requires the work of outside contractors who specialize in electrical cabling and rewiring. Because of the inherent difficulty of accessing a specific wire or cable from the numerous, and sometimes tangled masses of cables and wires concealed within walls or floors of the facility, obsolete and unusable cables are often left in place adding to the confusion and difficulty of maintaining or controlling such wiring.

Clearly, there is a need for a power distribution units and systems that address the concerns presented by conventional systems.

Summary of the Invention

New electrical power distribution apparatus and systems have been discovered. The present apparatus are compact in design, cost effective and labor and time saving. The present apparatus and systems provide versatility and flexibility in meeting electrical power requirements in both large and small facilities.

In one broad aspect, electrical power distribution apparatus in accordance with the invention comprise a housing and an electrical power input assembly, preferably located substantially in the housing, adapted to be connected to an electrical power supply, for example, a commercial power supply, preferably an uninterruptible power

supply or UPS, which is provided from a conventional power source, e.g., generating plant. The apparatus, and in particular, the housing, preferably is rack-mountable, for example, on a conventional 19 inch or 23 inch industry standard rack. This rack mountable feature is highly advantageous in that the present apparatus is compact, can be placed on a rack for easy installation and maintenance. This rack mountable feature provides the present apparatus with substantial benefits relative to conventional, free standing and large or bulky PDU's.

The apparatus in accordance with the invention further comprises a plurality of electrical power output assemblies, preferably located substantially in the housing, adapted to receive electrical power from the power input assembly. The power output assemblies may be mounted in a circuit panel that is removably mounted in the housing. Preferably, the plurality of output assemblies includes at least one output connection adapted to be hard-wired, for example, to a piece of equipment in a manner similar to hard-wiring equipment to a conventional power distribution unit. The plurality of output assemblies may, and preferably does, also include at least one output receptacle adapted to receive an equipment plug to provide electrical power, for example, to the equipment associated with the equipment plug. Thus, the present apparatus are effective in coupling directly to local pieces of equipment through conventional receptacles, as well as being hard-wired to remote pieces of equipment, or alternatively to one or more additional separate power distribution apparatus in accordance with the present invention. It is noted that the hard-wired output connection may hereinafter sometimes be referred to as an "external circuit", and the output receptacle or receptacle circuit may hereinafter sometimes be referred to as an "internal circuit".

In one advantageous embodiment of the invention, the

plurality of output assemblies may include a plurality of differently configured receptacles adapted to receive differently configured equipment plugs. This feature advantageously adds to the flexibility of the present apparatus.

In another aspect of the invention, each of the external circuits and/or internal circuits includes a different, individually operable circuit breaker, although more than one circuit, such as two or more internal circuits, can be associated with the same circuit breaker.

Unlike large, free-standing power distribution units, the present electrical power distribution apparatus may be adapted for receiving and distributing single phase power, thus making it convenient for small electrical applications. The apparatus, however, may also be adapted for use with a three phase power. Advantageously, the input assembly is adapted to be electrically connected to a single phase electrical power supply, or alternately to a three phase electrical power supply.

Preferably, the electrical power input assembly further comprises a meter, for example, located substantially in the housing, adapted to monitor at least one property of the electrical power passing through the input assembly. For example, the meter may be a voltage meter for monitoring voltage being provided to the apparatus. More sophisticated meters may be employed to provide enhanced electrical power monitoring. For example, a multi-function monitor, such as the 7300 ION-TRAN model sold by Power Measurement, may be advantageously employed.

In addition, a transformer, for example, a step down transformer, may be provided. The transformer preferably is adapted to be in electrical communication with both the electrical power supply and the input assembly. Because of the compact nature of the present apparatus, the transformer, which is often a substantial source of heat,

preferably is located outside the housing, for example, in the outdoors or other environment where the heat produced can be effectively dissipated.

In an additional aspect of the present invention,
5 electrical power distribution systems are provided. The present systems generally comprise a plurality of electrical power distribution apparatus configured such that each electrical power distribution apparatus is adapted to be electrically connected with at least one of the other
10 electrical power distribution apparatus. At least one, and preferably more than one, of the electrical power distribution apparatus included in the present systems is an apparatus in accordance with the present invention, for example, as described herein.

In one very useful embodiment, the present systems
15 provide a single primary electrical power distribution apparatus in electrical communication with one or more electrical power distribution apparatus in accordance with the present invention, for example, hardwired to the primary
20 power distribution apparatus through an output connection of the primary electrical power distribution apparatus. Such systems very effectively distribute electrical power while reducing the amount of wiring required for such distribution. Since each of the power distribution
25 apparatus included in the present systems preferably are effective to provide both receptacle circuits and hardwired circuits, each individual power distribution apparatus making up the system is able to provide power to pieces of equipment located close to the power distribution apparatus,
30 for example, using the receptacle circuits, and to pieces of equipment which are relatively remote from the power distribution apparatus, for example, using the output connections which are adapted to be hardwired to such pieces of equipment. The use of the present power distribution
35 apparatus in such electrical power distribution systems

takes advantage of the flexibility and versatility of the present electrical power distribution apparatus.

Any and all features described herein and combinations of such features are included within the scope of the present invention provided that the features of any such combinations are not mutually inconsistent.

These and other aspects of the present invention will become apparent in the following detailed description, particularly in conjunction with the accompanying drawings in which like parts bear like reference numerals, primed or followed by a,b,c, etc. as appropriate.

Brief Description of the Drawings

Fig. 1 is a circuit diagram of a power distribution apparatus in accordance with the present invention showing an electrical power input assembly and multiple, electrical power output assemblies including both local receptacles and remote output connections.

Fig. 1A is a circuit diagram of an alternative embodiment of the electrical power input assembly portion of the power distribution apparatus of Fig. 1.

Fig. 2 is a perspective view of a partially disassembled embodiment of a power distribution apparatus in accordance with the present invention.

Fig. 3 is a back view, in perspective, of the embodiment (assembled) shown in Fig.2.

Fig. 4 is a front view of the embodiment shown in Figs. 2 and 3, in which the apparatus has been mounted to an industry standard rack.

Fig. 5 is a diagram of a power distribution system, including a plurality of power distribution apparatus, in accordance with the present invention.

Detailed Description

Turning now to Fig. 1, a power distribution apparatus 10, in accordance with the invention is represented by a block circuit diagram. The apparatus 10 generally comprises an electrical power input assembly, represented generally at 14, adapted to receive power from an uninterruptible or substantially constant electrical power source or supply 18, and a plurality of electrical power output assemblies, represented generally at 20, adapted to receive and distribute electrical power from the input assembly 14. The power supply 18 may be provided by a commercial power source, for example, a single phase system or three phase system. Neutral and ground lines 24 and 26, respectively, are shown connecting the power supply 18 to a neutral bus bar 28 and a ground bus bar 30 respectively, as is conventional.

Electrical power through power input line 34 is passed through a transformer 36, of conventional design, adapted to be in electrical communication with both the electrical power supply 18 and the input assembly 14. The transformer 36 is a step-down transformer adapted to step down the voltage of the power from the power supply, for example, from 3 phase 480V AC in line 34 to 3 phase 208V AC in line 40.

The input assembly 14 includes an input circuit breaker 42 of conventional design. The input circuit breaker 42 functions to protect apparatus 10 against surges of high voltage or high current electrical power. In addition, a meter 50, for example, a volt meter and/or an amp meter, may be provided for measuring at least one property of the electrical power, for example, voltage and/or current, passing through the input assembly 14 along line 40. Further, a metal oxide varister, or MOV, 51 is provided in line 53 which extends from the high side of input circuit

breaker 42 to ground bus bar 30. MOV 51, of conventional design, functions to suppress power surges from power supply 18. It is to be understood that transformer 36, meter 50 and MOV 51 are optional so that apparatus including none,
5 one, two or all three of the components are included within the scope of the present invention.

In one embodiment, the reliability of input assembly 14 may be enhanced by providing a plurality of power sources and, in the event of a failure of one power source, allowing
10 the use of one or more of the other power sources. Referring now to Fig. 1A, two power sources 18a and 18b supply electrical power through power input lines 34a and 34b to input assembly 14'. In this embodiment, the power from the power sources 18a and 18b passes through a
15 transformer 36a or a transformer 36b, respectively. All of the transformers 36a and 36b used are of the same design as the transformer 36 of Fig. 1 and are adapted to be in electrical communication with both the respective electrical power sources 18a and 18b and the input assembly 14'.
20 Neutral and ground lines 24' and 26' are shown commonly connected with the power sources 18a and 18b, respectively, to neutral bus bar 28 and ground bus bar 30.

In this embodiment only one of the two power sources 18a and 18b is used to supply power at any one time. A
25 switch 38 is provided to supply power to line 40 at the point shown as in Figs. 1 and 1A as PS, thereby supplying power to input circuit breaker 42. The switch may be mechanical or static (electronic) (make before break) and configured to monitor the power and to switch from one power
30 source to another either automatically upon the failure of a power source or manually. This feature provides for continuous and redundant power to the final load. The switch can be of either the interruptible type or the noninterruptible type meaning a break-before-make switch or
35 a make-before-break switch. The noninterruptible type of

switch insures a power supply during the switchover from one power source to another, using, for example, a static switch electronically or mechanically operated to provide a overlap between the two power sources or a backup battery as an interim power supply.

Electrical meter 50 and MOV 51 may also be used with the input assembly 14' in the same manner and to the same advantage that they are used as shown in Fig. 1.

Referring again to Fig. 1, the electrical power output assemblies 20 are adapted to provide electrical power to both remote locations by cable connections and to local electronic components and other equipment. More particularly, the electrical power outputs 54 from the output assemblies 20 include a plurality of output connections 56 adapted to be hard-wired to pieces of electrical equipment, for example, main frame computer 62, in a manner similar to connecting a conventional PDU to such a piece of equipment. Preferably, at least about eight output connections 56 are provided, although the number can range up to about 30 or about 40 or more.

The electrical power outputs 54 further include a plurality of electrical output receptacles 64 adapted to receive a pronged plug 66 for providing power to a local piece of equipment, for example, a personal computer 68, located near the apparatus 10. The number of output receptacles can range up to about 40 or about 50 or more. It is noted that the term "electrical output receptacles" is considered herein to include various standard and non-standard plug receptacles, as well as any suitable wiring means for connecting the power input assembly 14 to such various plug receptacles. In one embodiment of apparatus 10, a plurality of differently configured receptacles, adapted to receive differently configured plugs, are provided.

It is to be appreciated that the present power

distribution apparatus 10, in accordance with the present invention, may be configured such that the plurality of electrical power outputs 54 include at least one output, and preferably a plurality of output connections 56, adapted to
5 be hard wired to a remote location or equipment, and at least one output receptacle 64, and preferably a plurality of output receptacles 64, plug for providing power to a local piece of equipment.

However, the output receptacles 64 may be optional.
10 When utilizing a single phase power supply through input assembly 14, the present apparatus 10 offers the advantage of being a compact, for example, rack mountable, power distribution apparatus having the capability of being connected to remote equipment through external connections
15 or circuits 56. The apparatus 10 may thus be used as a distribution sub-system providing an electrical interface, or distribution center, between a conventional PDU and several components of equipment, including remote, electric equipment which is hardwired to the apparatus 10.

20 In one embodiment of the invention, each of the output connections 56 and output receptacles 64 is associated with a different, i.e. independently operable, circuit breaker 66. Such circuit breakers 66 act or function to provide surge protection for the individual pieces of equipment, for
25 example, main frame computer 62 and personal computer 68, electrically connected to apparatus 10. Of course, if desired, two or more output connections 56 or two or more output receptacles 64 can be associated with the same output circuit breaker 66.

30 The invention may be more clearly understood with respect to Figs. 2, 3 and 4 which show a preferred embodiment of the apparatus 10. The apparatus 10 preferably comprises a housing 70 made of one or more suitable materials of construction, such as steel, aluminum, and the
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the "external" output connectors 56. One of the knockouts 106 may be used to provide access for insertion of an input cable (not shown in Fig. 2) from the power supply 18, in which lines from a power input cable are connected to circuit breaker 42 (through transformer 36), neutral bus or bar 28 and ground bus or bar 30. It is noted that when the power supply is a three phase electrical power supply, the input circuit may include three power input lines ("hot" lines) carrying 208 V. For distributing power from a one or single phase power supply, two hot lines carrying 208V or alternatively 1 hot line carrying 120 V may be provided.

An important aspect of the invention is shown in Fig. 4. More specifically, the housing 70 is rack-mountable. For example, the housing 70 may be appropriately sized, and include external mounts 110, for enabling the apparatus 10 to be mounted on a conventional 19 inch or 23 inch, or other small sized, industry standard rack 112. For example, the housing 70 may have a length, height and depth measurement of about 17 X 19 X 5 inches. Fasteners, such as conventional nut/bolt combinations 114 are employed to secure housing 70 to rack 112. In the embodiment shown, a power supply input cable 116 and two electrical power output cables 118 are connected through top and bottom panels 102, 104 of the housing 70 by suitable mounting connectors 122.

A power distribution system 210 in accordance with the present invention is shown in block diagram in Fig. 5. Preferably, the system 210 comprises a plurality of electrical power distribution apparatus 220, 230, 240 and 250 made in accordance with the present invention as described herein, wherein each of the apparatus 220, 230, 240 and 250 receives electrical power supplied by a main power source, for example, commercial power supplied through primary power distribution unit 250. The system 210 may be used to supply and distribute electrical power through a building or other facility (not shown). Each of the

apparatus 220, 230, 240 and 250 include multiple output connectors (external circuits) 261, as well as multiple output receptacles (internal circuits) 263. It is to be appreciated that each apparatus 220, 230, 240 is
5 electrically connected to apparatus 250 through an output connector 261, as shown in Fig. 5. In one embodiment, primary power distribution unit 250 can be replaced by a conventional PDU which has only hard-wired circuits.

The present apparatus 10 and system 210 have the
10 capacity to meet the power requirements and needs of both large and small facilities. As can be appreciated, the apparatus 10 and system 210 reduce or substantially eliminate many of the problems associated with conventional power distribution units and systems. The present apparatus
15 and systems also greatly facilitates trouble shooting when electrical problems arise, thereby reducing maintenance costs and employee down-time. For example, if an electrical problem arises at one workstation, the problem can be quickly tracked and investigated without the need to
20 eliminate power to other workstations that are functioning satisfactorily. This is made possible by means of different and separately operable circuits made available through the present power distribution apparatus and systems.

While this invention has been described with respect to
25 various specific examples and embodiments, it is to be understood that the invention is not limited thereto, and that it can be variously practiced within the scope of the following claims.